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HOMEMADE LIME-SULPHUR CONCENTRATE.

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During the past few years much attention has been given by investigators to the home preparation of lime-sulphur concentrate and also to an inquiry into the chemical reactions involved, as affecting the conditions under which the work should be done. These investigations have had for their purpose the encouragement of orchardists in the preparation of concentrates for their own use, or for the use of the neighborhood. The success of these efforts is shown by the fact that many fruit growers now prepare their own lime-sulphur concentrates, thus effecting a material saving over the cost of the commercial article.

Orchardists, as a rule, are not able consistently to obtain a product of uniform density, even though the same formula be employed and the work be accomplished as nearly as possible in an identical manner for the different batches. This defect, however, is really of little importance, since it is easy to test the density of the concentrate and make dilutions in conformity with the purpose for which it is to be used.

During the past few years the Bureau of Entomology has given attention to the making of lime-sulphur concentrates in connection with work in deciduous-fruit insect investigations. No particular chemical study was planned in connection with these cooking tests, as it was merely desired to know the degree of density and percentage of the "sludge" which would result by the employment of different formulas. The cooking tests for the most part were made at lime-sulphur plants operated by orchardists, or by individuals who supplied the concentrate to orchardists in the immediate territory.

EXPERIMENTS AT BERRYVILLE, VA.

Six experiments were conducted at a small plant at Berryville, Va. This plant consisted of a 12-horsepower boiler and two 150-gallon cooking vessels. The cooking was done by steam which was

Note.—Describes experiments in making lime-sulphur concentrates and gives the most satisfactory formulas. Of interest to all practicing spraying in insecticide work.

ejected through perforated coils in the bottom of the tanks. There was no mechanical agitator, the mixture being agitated by hand by the use of a long wooden paddle. The mixture was allowed to cook 50 minutes, when, after taking samples for testing purposes, the remainder was drained into a storage tank. The results of these tests are given in Table I.

TABLE I.—*Results of cooking different lots of lime and sulphur in preparation of lime-sulphur wash, Berryville, Va., 1912.*

Experiment No.	Formula.			Percentage in volume of sludge.	Degrees Baumé.
	Lime.	Sulphur.	Water.		
	Pounds.	*Pounds.*	*Gallons.*		
1	50	100	50	39.0	28.5
2	50	100	50	50.0	30.0
3	50	100	50	35.0	29.5
4	50	100	50	41.5	30.5
5	45	100	50	41.0	29.0
6	55	100	50	44.0	28.0

The 50–100–50 formula was used in the first four of these experiments. The Baumé test of the cooked wash varied from 28.5° to 30.5°, and the percentage in volume of sludge, after standing 24 hours, varied from 35 to 50. The preparation of the wash in experiments 1 and 3 was as nearly the same as was possible, the lime being added first and the sulphur immediately afterwards. In experiment 2 the sulphur was added first.

In experiment 4 the mixture was not stirred after the steam was turned on, the steam being depended upon for agitation. Otherwise the treatment was the same as in experiment 1.

In experiments 5 and 6 the quantity of lime was decreased and increased 5 pounds, respectively, from the amount previously used. This was done to determine, if possible, whether more or less of this particular brand of lime should be used. In every other respect the treatment was the same as in experiment 1. The only points considered in this experiment were the Baumé test and the percentage in volume of sludge.

EXPERIMENTS AT WINCHESTER, VA.

A lime-sulphur cooking plant located at Winchester, Va., also was visited. This plant, which has a capacity of 500 gallons per day, consists of a 150-gallon rectangular sheet-iron tank embedded in a brick furnace in which wood is burned to furnish the heat. This plant supplies a number of the surrounding fruit growers with lime-sulphur solution. As soon as the cooking has been completed, the solution is piped directly through a 20-mesh strainer into 50-gallon barrels and is delivered to the growers without being filtered. The strainer, of course, takes out only the coarser particles; therefore it is necessary for the grower thoroughly to shake the barrel each time

any of the solution is taken out in order to get an even distribution of the sludge. The following data were obtained, which show the variation in density of the different batches. Four batches in which the 50–100–50 formula was used tested 25°, 26°, 28°, and 29° Baumé, respectively. Seven batches in which the 55–110–50 formula was used tested 28°, 29°, 29°, 30°, 30°, 30°, and 31° Baumé, respectively. It will be noted that there was considerable variation in degrees Baumé for the different batches, although each was cooked as nearly as possible in the same way.

Similar variations in density were observed at a steam-cooking plant at Chewsville, Md.

EXPERIMENTS AT HAGERSTOWN, MD.

A new lime-sulphur cooking plant at Hagerstown, Md., was visited. The cooking vessels, two in number, consisted of the hulls of two large boilers standing on end. Each held about 1,500 gallons. The cooking is done by steam. A few experiments were conducted at this plant to determine, if possible, what formula should be used under these conditions of manufacture to obtain a highly concentrated solution. The results of these trials are given in Table II.

TABLE II.—*Results of cooking different lots of lime and sulphur in preparation of lime-sulphur wash, Hagerstown, Md., 1912.*

Experiment No.	Formula.			Percentage in volume of sludge (estimate).	Degrees Baumé.
	Lime.	Sulphur.	Water.		
	Pounds.	*Pounds.*	*Gallons.*		
1	800	1,600	800	35.0	25.5
2	800	1,600	800	35.0	26.0
3	750	1,500	285 gallons sludge, 715 gallons water.....	40.0	23.0
4	200	400	Added to above 1,000 gallons of 23° Baumé material	45.0	27.0
5	1,000	2,000	280 gallons sludge, 620 gallons water.....	45.0	32.5

In Experiments 1 and 2 800 gallons of solution were cooked at a time. The 50–100–50 formula was used in each of the two experiments with a result of 25.5° and 26° Baumé test solution respectively. In each case there was about 35 per cent in volume of sludge. The solution in Experiment 1 was allowed to remain in the vessel 24 hours, then the clear solution was drawn off and 285 gallons of sludge remained in the tank. In order to see what effect this sludge would have on the solution by cooking it over with the next batch (Experiment 3), 715 gallons of water were added to it, making 1,000 gallons in all; 750 pounds of lime and 1,500 pounds of sulphur were added to this and the mixture was cooked for one hour. After allowing the solution to settle 24 hours the clear liquid tested 23° Baumé and there was 40 per cent in volume of sludge. An attempt was made to raise the test of this solution (Experiment 4) by adding

to it 200 pounds of lime and 400 pounds of sulphur. After cooking this for an hour and allowing it to settle there was 45 per cent in volume of sludge and the clear solution tested 27° Baumé. In an attempt to make a high-test solution by using a reduced quantity of water mixed with sludge Experiment 5 was conducted. To the 280 gallons of sludge remaining in the cooking vessel from Experiment 2 there were added 620 gallons of water, making a total of 900 gallons. To this was added 1,000 pounds of lime and 2,000 pounds of sulphur. This was cooked for one hour, and after allowing it to settle for 24 hours there was 45 per cent in volume of sludge, and the clear solution tested 32.5° Baumé. It will be seen that a high-test solution was obtained by reducing the quantity of water, but the percentage of sludge was also considerably increased.

EXPERIMENTS AT VIENNA, VA.

A few lime-sulphur cooking experiments were conducted at Vienna, Va., in the spring of 1911. A large iron pot placed over a wood fire was used as a cooking vessel. In four of these experiments the 50–100–50 formula was used. The time of cooking was from 45 minutes to one hour. The results, which show variation in Baumé test and a high percentage in volume of sludge, are given in Table III.

TABLE III.—*Results of cooking different lots of lime and sulphur in preparation of lime-sulphur wash, Vienna, Va., 1911.*

Experiment No.	Formula.			Percentage in volume of sludge.	Degrees Baumé.
	Lime.	Sulphur.	Water.		
	Pounds.	*Pounds.*	*Gallons.*		
8	8	16	8	40.0	30.6
9	40	80	40	33.0	28.8
10	40	80	40	40.0	28.7
11	40	80	40	50.0	27.0

EXPERIMENTS AT BENTON HARBOR, MICH.

Some experiments were conducted at Benton Harbor, Mich., in the fall of 1912 for the purpose of making high-test solutions. The cooking plant consists of a 12-horsepower boiler from which steam is conducted into two 50-gallon barrels. There are no coils in the bottom of the barrels, the steam simply being emitted through the open end of a straight pipe extending to within a few inches of the bottom of the barrel.

Small batches amounting to 25 gallons of the finished product were cooked at a time. About 20 gallons of water were put into the barrel, then the steam was turned on and the water brought to boiling. The lime was then put in and after it had begun to slake the sulphur was

added. The mixture was stirred thoroughly throughout the time of cooking, which lasted 1 hour. It was allowed to settle about 12 hours, and then the clear solution was siphoned off. The sludge was put into a cider press and the clear solution pressed out, using 10-ounce canvas cloth for filter. A good grade of stone lime was used in experiments 1 to 5. Hydrated lime was tried in experiments 6 and 7. Commercial ground sulphur was used in all the experiments. The results are given in Table IV.

TABLE IV.—*Results of cooking different lots of lime and sulphur in preparation of lime-sulphur wash, Benton Harbor, Mich., 1912.*

Experiment No.	Formula.				Degrees Baumé.
	Lime.	Sulphur.	Water.	Sediment.	
	Pounds.	*Pounds.*	*Gallons.*	*Pounds.*	
1	25	50	25	32	27.0
2	25	50	25	36	27.0
3	40	80	25	80	34.0
4	40	80	25	90	35.5
5	40	80	25	85	32.5
6	[1] 60	80	25	110	30.0
7	[1] 60	80	25	100	31.5

[1] Hydrated.

In Experiments 1 and 2 the 50–100–50 formula was used, with a result of 27° Baumé test solution in each case and 32 pounds of sludge in Experiment 1 and 36 pounds in Experiment 2. In Experiments 3, 4, and 5 the same proportion of lime and sulphur as above stated was used, but the amount of water was reduced, the formula being 40 pounds of lime and 80 pounds of sulphur and water to make 25 gallons of concentrate. The Baumé tests of these three batches varied from 32.5° to 35.5°, and the amount of sludge varied from 80 to 90 pounds. The sludge, after it had been run through the cider press, was in the form of a thick paste, so the number of pounds given does not nearly represent the number of pounds of dry sediment.

The formula used in the last two experiments was 60 pounds of hydrated lime and 80 pounds of sulphur with water to make 25 gallons of concentrate. Where the hydrated lime was used the solution did not test so high and there was considerably more sludge.

DIRECTIONS FOR PREPARATION OF LIME-SULPHUR CONCENTRATE.

The 50–100–50 formula has been generally recommended for the preparation of home-boiled concentrated lime-sulphur solution. The method of preparation is to boil together for 50 minutes to 1 hour 50 pounds of lime, 100 pounds of sulphur, and water to make 50 gallons of the concentrated solution. A good grade of fresh stone lime containing not less than 90 per cent of calcium oxid is necessary for the best results. Hydrated lime is sometimes used,

but it is necessary to use a good grade and at least 20 per cent more of this form of lime, as it contains a high percentage of moisture.

Place enough water in the cooking vessel to finish with 50 gallons of the solution. Bring the water to the boiling point, start the agitator, if the plant is equipped with one, then put in the lime and immediately add the sulphur. The mixture should be stirred vigorously either mechanically or by hand until the lime is slaked. Agitation should be continued throughout the time of cooking, which should not exceed one hour. If the solution is to be barreled without filtering, it should be drawn off immediately and allowed to run through a 30-mesh strainer into the barrels. The agitation should continue until all the solution is drawn off, so that there will be an equal distribution of the sludge in the different barrels.

PREPARATION OF HIGHLY CONCENTRATED LIME-SULPHUR SOLUTION.

From the experiments above reported, it is evident that a highly concentrated lime-sulphur solution may be made by using the lime and sulphur at the ratio of 1 to 2 as is usually recommended, but with reduced quantities of water. The formula used in the commercial lime-sulphur manufacturing plants visited and also in the foregoing experiments is as follows:

Fresh stone-lime	pounds..	80
Commercial ground sulphur	do....	160
Water to make the finished product	gallons..	50

While there is about 50 per cent in volume of sludge after allowing this solution to settle for 24 hours, there is only about 5 to 10 per cent in volume of insoluble materials. These consist of sulphites, free lime, free sulphur, magnesium compounds, etc., varying with the kind of lime used and other conditions. Solutions prepared by this formula should test on an average 33° to 34° Baumé.

RELATIVE COST.

Commercial ground sulphur can be bought in car lots for about $1.50 per hundred pounds, and lime at about 60 cents per barrel. At these prices the highly concentrated solution can be made at the following cost per barrel:

80 pounds lime at 60 cents per barrel	$0.20
160 pounds sulphur at $1.50 per hundredweight	2.40
Labor and fuel, estimated	.70
Total cost per barrel of 50 gallons	3.30

This does not include interest and wear on outfit, and cost of containers for storing. At the foregoing prices of ingredients the high-test concentrate would cost about 98 cents more per barrel than the lower-test concentrate made by the 50–100–50 formula.

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